CDB Engineering S.p.A

STEAM TRAPS MANUAL

In industrial installations the plant engineering is often faced with steam and condensate problems, the nature of which is not always readily understood. Frequently they are connected with an inefficient condensate discharge, but, in many cases other disturbance may be the cause.
This publication, which does by no means pretend to be exhaustive, is meant to be a practical guide, giving some indications which may contribute towards a greater plant efficiency, particularly in respect of steam distribution and of steam as an industrial heating medium. Avoid –ing theoretical consideration wherever possible, various disturbing phenomena will be examined, together with their possible causes and remedies.
Furthermore we shall discuss the major steam trap construction, indicating their advantages and disadvantages, enabling the user himself to select the correct apparatus for his particular operating conditions.
Throughout the years many different steam trap designs have been developed but we submit that as yet the universal steam trap, suitable for all applications, has not been invented. The customer's choice must therefore always be a compromise between cost, life and efficient functioning in given service conditions.
Please don't hesitate to consult our technical department for any additional advice you may require or for any particular condensate problem you may be faced with.

Selecting the proper type of steam trap is an important element in steam systems. There are many types of steam traps each having its unique characteristics and system benefits. Deciding which type of trap to use is sometimes confusing and, in many cases, more than one type can be used. The following is intended to point out system conditions that may be encountered and the characteristics of each type of trap. Within steam systems, important considerations must be taken into account. These considerations include venting of air during start-up; variations of system pressures and condensing loads; operating pressure and system load; continuous or intermittent operation of system; usage of dry or wet return lines; and overall probability of water hammer.

Air Venting
At start-up all steam piping, coils, drums, tracer lines, or steam spaces contain air. This air must be vented before steam can enter. Usually the steam trap must be capable of venting the air during this start-up period.
A steam heating system will cycle many times during a day and fast venting of air is necessary to obtain fast distribution of steam for good heat balance. A steam line used in process may only be shut down once a year for repair and venting of air may not be a major concern.

Modulating Loads
When a modulating steam regulator is used, such as on a heat exchanger, to maintain a constant temperature over a wide range of flow rates and varying inlet temperatures, the condensate load and differential pressure across the trap will change. When the condensate load varies, the steam trap must be capable of handling a wide range of conditions at constantly changing differential pressures across the trap.

Differential Pressure Across Trap
When a trap drains into a dry gravity return line, the pressure at the trap discharge is normally at O psig.
When a trap drains into a wet return line or if the trap must lift condensate to an overhead return line, there will normally be a positive pressure at the trap discharge. To assure condensate drainage, there must be a positive differential pressure across the trap under all load conditions..

Water Hammer
When a trap drains high temperature condensate into a wet return, flashing may occur. When the high temperature condensate at saturation temperature discharges into a lower pressure area, this flashing causes steam pockets to occur in the piping, and when the latent heat in the steam pocket is released, the pocket implodes causing water hammer. Floats and bellows can be damaged by water hammer conditions.
When traps drain into wet return lines, a check valve should be installed after the trap to prevent backflow.
The check valve also reduces shock forces transmitted to the trap due to water hammer. Where possible, wet returns should be avoided..

Application

The design of the equipment being drained is an important element in the selection of the trap. Some equipment will permit the condensate to back up. When this occurs the steam and condensate will mix and create water hammer ahead of the trap. A shell and tube heat exchanger has tube supports in the shell. If condensate backs up in the heat exchanger shell, steam flowing around the tube supports mixes into the condensate and causes steam pockets to occur in the condensate. When these steam pockets give up their latent heat, they implode and water hammer occurs, the water hammer often damages the heat exchanger tube bundle. The trap selection for these types of conditions must completely drain condensate at saturation temperature under all load conditions.

Steam mains should be trapped to remove all condensate at saturation temperature. When condensate backs up in a steam main, steam flow through the condensate can cause water hammer. This is most likely to occur at expansion loops and near elbows in the steam main.

Applications such as tracer lines or vertical unit heaters do not mix steam and condensate. In a tracer line as the steam condenses, it flows to the end of the tracer line and backing up of condensate ahead of the trap does not cause water hammer as the steam does not pass through the condensate.

Vertical unit heaters normally have a steam manifold across the top and, as the steam condenses in the vertical tubes, it drains into a bottom condensate manifold. As the steam does not pass through the condensate, water hammer normally would not occur.

A review of the trap operating principle will show how various types of traps meet the different system characteristics.

Having gone to a lot of expense in generating steam and installing a distribution system we now need to get it to it's various users around the plant as efficiently as possible. ***Efficiency translates into getting it to the users with a minimal loss in latent energy at a reasonable cost***. This is where the steam trap comes in.

Without steam traps unabated condensate would form in distribution piping, creating a wide range of problems. In addition there would be no essential control at the users. Steam would enter a set of tubes or a coil at one end and come out the other as either steam, condensate or a two-phase mixture of the two; very dangerous, damaging and wasteful.

By installing steam traps in strategic locations throughout the distribution system we can alleviate those problems. A steam trap on the outlet side of a heat exchanger allows the steam to reside there until all of the latent heat energy is transferred and the accumulated condensate is carried off. ***With proper placement and specification of steam traps for these purposes we can create and maintain an efficient, cost effective steam supply and distribution system***. In knowing this, the next step is to determine the best trap to use for a given application. So lets take a look at the various types of traps and what each is or is not suited for.

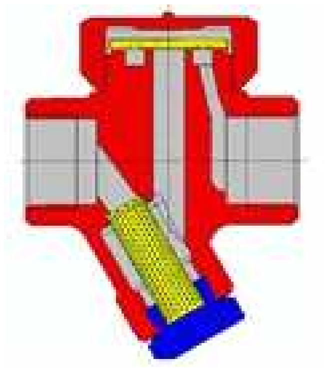
In identifying steam traps we can break them down into three main groups: Thermodynamic, Thermostatic and Mechanical.

THERMODYNAMIC: In addition to downstream flash steam assist, this type of trap operates on the difference in velocity or kinetic energy between steam and condensate passing through a fixed or modulating orifice.

THERMOSTATIC: This type of trap operates on the principle of expanding liquids and metals used to drive a valve into or back it away from a seat.

MECHANICAL: This trap is made up of mechanical apparatus that are driven by the density of the condensate to operate a float or a bucket.

On a generic basis, let us take a look at the various types of traps within each group. Generic is used because the various manufacturers have several different designs of the same basic trapping principle. What we will discuss here are the primary trap designs in each category. For instance, within the Thermodynamic category of traps there are the orifice, disc, impulse or piston and labyrinth types. We will only discuss the orifice and disc types because of their predominance.



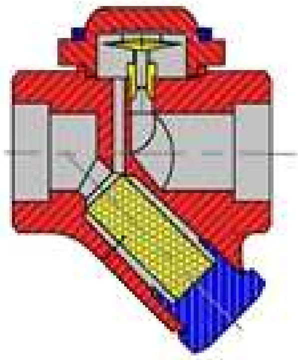
THERMODYNAMIC STEAM TRAPS

Aside from the orifice trap this is probably the simplest trap on the market and yet is the most widely used. The disc trap is made up of three primary components: the body, the cap and the disc. Like the orifice trap, the operation of the disc trap utilizes the difference in specific volume between steam and condensate. With flow moving through a fixed orifice this translates into a difference in velocity between steam and condensate. Operation of the disc trap also utilizes flash steam as an operating force to work in conjunction with the velocity of the steam.

In order to understand the operation of the disc itself we have to know the principle under which it operates.

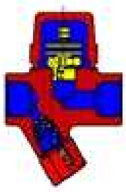
Bernoulli's Principle, simply stated: THE PRESSURE OF A FLUID (LIQUID OR GAS) DECREASES AT POINTS WHERE THE SPEED OF THE FLUID INCREASES.

Applying this to the disc trap we are, in fact, creating a low pressure zone between the disc and seats whenever we increase the velocity of the steam or condensate flowing through this zone. In addition we are providing a small chamber for the accumulation of flash steam above the disc. Fig. shows a simple disc trap. As flow, in the form of condensate, moves into the trap and through the inlet orifice it forces the disc to lift, allowing the condensate to pass through and out the outlet. As the temperature of the condensate reaches it's saturation point a percentage of that condensate will flash as it exits the inlet orifice. When steam reaches the inlet orifice two things will immediately happen: the velocity will increase sufficiently to create a low pressure zone between disc and seats pulling the disc down upon the seats. At the same time flash steam will have formed behind the disc and, with the exit orifice sealed off, the pressure induced by this non-escaping flash steam will hold the disc in place. The disc will remain in place until the flash steam has condensed, thus allowing the disc to open again. Size 1/2" to 2" rating 600# to 2500#



THERMOSTATIC STEAM TRAPS
Balanced Pressure

The Balanced Pressure type trap operates on the principal of liquid expansion due to an increase in temperature. The liquid is contained in a bellows internal to the steam trap and fixed at one end. Integral to the bellows is a valve attached to its free end. The liquid in the partially filled bellows can be as simple as distilled water under vacuum or an alcohol combination to reduce its vapor point to a lower degree than water. At ambient conditions the bellows is contracted with the valve away from the seat. When steam, or condensate near it's saturation point, comes in contact with the bellows the liquid inside the bellows expands and drives the valve into the seat closing off steam flow. As the steam condenses, collects and cools, the bellows will cool and contract, backing the valve away from the seat and allowing the accumulated condensate to pass. As the condensate passes through the trap and is replaced by steam the bellows heats up again. As steam comes in contact with the bellows it expands and closes the valve, shutting off flow. As you can see this trap is not governed not only by the pressure differential but rather by the temperature of the steam and condensate. Size 1/2" to 2" rating up to 300#



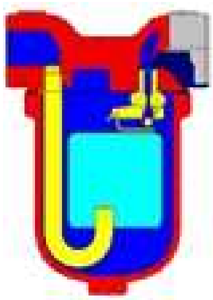

THERMOSTATIC STEAM TRAPS
Bimetallic

Like the Balanced Pressure trap, the Bi-Metallic trap is also governed by temperature variations. However, as the name suggests it does so by utilizing the differing expansion rates of metals when exposed to temperatures above or below ambient.

By laminating two dissimilar metal strips and exposing the resulting composite to elevated temperatures the differing expansion rates of the composite metal strip will cause it to bow. The higher the temperature the more extreme the bow.

The reaction of the Bi-Metal composite is utilized in several different forms with various valve and seat arrangements. The two most widely used designs are variations of the bellows style. One uses Bi-Metal circular discs. The two sets of Bi-Metal laminates are joined at the perimeter with the metal layer of each Bi-Metal disc having the lower rate of expansion facing each other. Several sets of these joined discs may be stacked to increase the force applied when they expand.

Through the center of the stacked discs is a rod, which is attached to the upper most disc. The rod runs through the sets of discs then through a seated orifice. At the end of the rod is a valve. In the relaxed or ambient condition the discs are flat against one another. In their hot condition each set expands against itself causing the bellows to expand. As the bellows expands it draws the valve into the seat of the orifice blocking off the flow of steam. Size ½" to 8" class up to 2500#



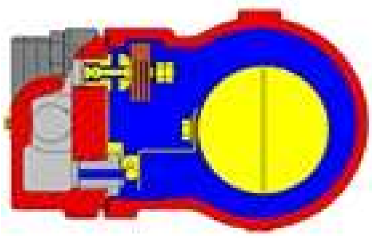
INVERTED BUCKET STEAM TRAPS

Next to the Disc Trap this is the most widely used trap in the industry. It can arguably be said that this trap is overused. It has such a wide use range that it is probably specified out of misunderstanding in a large number of situations. These aren't necessarily situations where this type of trap wouldn't work but rather situations where a less expensive, smaller, possibly longer lasting type of trap could have been applied.

This trap operates with an inverted bucket that float when steam is present and sinks when condensate exceeds liquid level. When the bucket float, the valve is closed, when it sinks the valve, will open

This trap is specified based on the differential pressure between the inlet and outlet pressures of the trap. With the length of the valve lever fixed the differential pressure is used to determine the weight of the bucket. The result allows the bucket to lift and reset the valve after dumping its condensate. The calculated weight of the bucket also allows the bucket to drop against the upstream pressure when it's full of condensate. Size ½" to 2" rating up to 1500#

BALL FLOAT AND THERMOSTATIC STEAM TRAPS



As the name implies, the Float & Thermostatic Trap utilizes two individual mechanisms that operate in conjunction with one another. The float operates a valve that controls the discharge of condensate. The thermostatic element controls the release of air and CO_2. The float itself, which is normally a ball type, is located in the lower portion of the trap body. It is attached to a rod which is, in turn, attached to the body of the trap in such a way that it is free to pivot about that point, allowing the float the freedom to move vertically. Near the end where the rod is attached to the body a valve is attached to the rod. The valve is positioned so that when the float is at rest the valve is seated in the outlet of the trap.

The thermostatic element is located in the upper part of the trap body. One end of the element is fixed allowing the opposite end with an attached valve to move in and out of a seated vent discharge opening located in the body of the trap. That vent discharge is connected to the discharge for the condensate. In its relaxed position the valve is pulled away from the seat.

CDB produce also Ball float to eliminate condensate from Compressed Air and Gas and for Liquid System. Size ½" to 4" rating up to 600#

TESTING STEAM TRAP OPERATION

We recommend three simple methods to test the operation of steam traps:

- With an electronic ultrasound assembly.
- With an engineers stethoscope.
- By observing the discharge of the trap. (requires isolation ball valves)
- Installation of automated steam trap performance monitoring system.

The electronic ultrasound assembly is the preferred choice. The operating principle is quite simple. When gas under pressure discharges thru a small orifice, an ultra sonic sound component is generated. The frequency and intensity of the ultrasonic sound produced, depends upon the orifice profile, and the gas pressure. These units work well will all types of traps, however, the operator must know what to listen for, depending upon the type of trap he is testing, and its discharge characteristics. The electronic ultrasound detector makes regular test and inspection of trap operation, a real breeze. No plant engineer should be without such an instrument!!

The engineers stethoscope is an old technique that works well with bucket, and float traps, but can be difficult to determine other types trap cycling, where minimal mechanical movements or actions are involved.

This method cannot detect the ultrasonic sound component of condensate discharging thru the orifice. It detects the audible sound of the mechanical parts in motion as the trap cycles.

The trap discharge method requires at least two isolation valves, and a discharge pipe. Here the trap is isolated from the condensate return line by one valve, the other valve opens the path to the discharge pipe, where steam and condensate can be observed to discharge when the trap cycles.